Two-Photon Excitation of Quantum Dots in 3D via Stacked Fresnel Hologram Algorithm

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Quantum dots are engineered to have nanometers dimensions. The ability to specify the diameter and the material of the quantum dots allow us tune the absorption and emission properties. This results in extensive capabilities for imaging [1] and display [2] applications. Further, with two photon absorption and high peak power laser they can be excited at any point in 3D locally [3].

Here, we used CdSe core, CdZnS shell quantum dot solution that has peak absorption/emission around 400/610 nm and locally excite the quantum dots in 3D, by employing a single Fresnel Hologram [4]. The algorithm used to generate the multi-plane projecting hologram allows 3D projection with high flexibility utilizing iterative Fourier transform algorithms and Fresnel Zone Plates. Hence, we were able to excite quantum dots in 3D by using a single hologram.

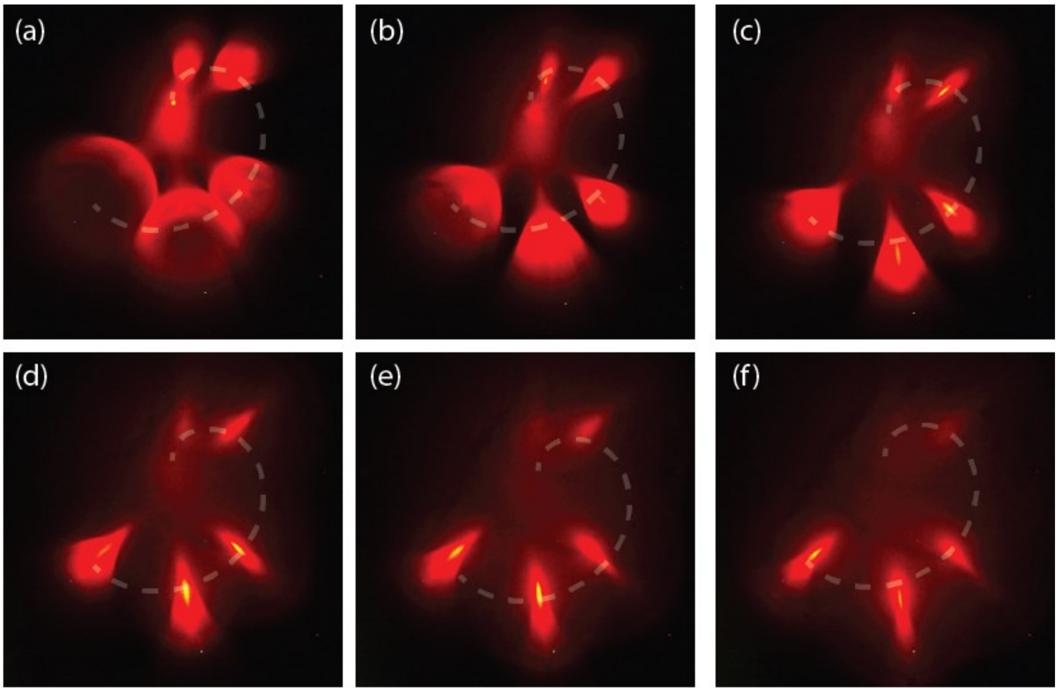

Fig. 1: Experimental Results: Quantum dot solution is excited at 6 points forming a helix in 3D. The imaging plane is moved from the outer most focal point to the closest with discrete steps (a-f). The dimensions of the helix is 0.3 mm x 0.3 mm x 1.5 mm.

The optical setup consists of a custom built femtosecond Yb-fibre laser centred at 1030 nm, spatial light modulator (SLM) and quantum dot solution. An inverse telescope is constructed between quantum dot solution and SLM to increase numerical aperture of 3D projection of hologram, so that the two photon excitation is achieved and confined in 3D. The images were taken with a CCD camera and 10X objective. Helix projection of 6 points is feeded to the algorithm and the resulting kinoform of Fresnel hologram is sent to SLM. The experimental reconstruction of the 6 points are given in Figure 1.

This method, which enables us to project to multiple planes simultaneously in 3D, is promising towards 3D displays with high frame rate and contrast. Further, it can be extended to biological imaging due to the use of quantum dots and can be used with compressive imaging techniques to improve the acquisition time.

References

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978-1-5090-6736-7/17/$31.00 ©2017 IEEE